

WHAT IS CLAIMED IS

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1. A quantum optical semiconductor device,  
comprising:

a semiconductor substrate; and

an active layer formed on said semiconductor  
10 substrate and including therein a quantum structure,  
said quantum structure comprising:

a first barrier layer of a first  
semiconductor crystal having a first lattice constant  
and a first bandgap;

15 a second barrier layer of a second  
semiconductor crystal formed epitaxially on said first  
barrier layer, said second semiconductor crystal  
having a second lattice constant and a second bandgap;

a plurality of quantum dots formed in said  
20 second barrier layer, each of said quantum dots  
comprising a semiconductor crystal forming a strained  
system with regard to said first and second  
semiconductor crystals and having a lattice constant  
different from said first lattice constant and a  
25 bandgap smaller than any of said first and second  
bandgaps, each of said quantum dots having a height  
substantially identical with a thickness of said  
second barrier layer; and

a third barrier layer of a third  
30 semiconductor crystal formed on said second barrier  
layer, said third semiconductor crystal having a  
lattice constant different from said lattice constant  
of said semiconductor crystal constituting said  
quantum dot, said third semiconductor crystal further  
35 having a third bandgap larger than said bandgap of  
said semiconductor crystal forming said quantum dot,  
said third barrier layer making a contact

with an apex of said quantum dot formed in said second barrier layer.

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2. A quantum optical semiconductor device as claimed in claim 1, wherein said second and third barrier layers form together a continuous, single  
10 semiconductor layer.

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3. A quantum optical semiconductor device as claimed in claim 1, wherein said first barrier layer has a composition modified in the vicinity of said quantum dot, and wherein said third barrier layer has a composition modified in the vicinity of said quantum  
20 dot.

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4. A quantum optical semiconductor device as claimed in claim 3, wherein each of said first through third barrier layers is formed of a group III-V mixed semiconductor crystal containing In and Ga, each of said first and third barrier layers having an  
30 increased In content in the vicinity of said quantum dot.

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5. A quantum optical semiconductor device as claimed in claim 4, wherein said second barrier layer

has an increased Ga content in the vicinity of said quantum dot.

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6. A quantum optical semiconductor device as claimed in claim 1, wherein each of said first semiconductor crystal, said second semiconductor  
10 crystal and said third semiconductor crystal achieved lattice-matching with respect to said semiconductor substrate.

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7. A quantum optical semiconductor device as claimed in claim 1, wherein said first and third semiconductor crystals have an identical composition.

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8. A quantum semiconductor device as claimed  
25 in claim 1, wherein said second lattice constant is larger or smaller than any of said first and third lattice constants.

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9. A quantum semiconductor device as claimed in claim 1, wherein each of said first through third semiconductor crystals is selected from the group  
35 consisting of an InGaAsP mixed crystal, an InAlGaAs mixed crystal, and an InAlGaP mixed crystal.

10. A quantum optical semiconductor device  
as claimed in claim 1, wherein each of said quantum  
dots has an in-plane strain equal to or larger than a  
strain acting in a direction perpendicular to said  
5 substrate for the case a tensile strain is defined to  
have a positive value and a compressive strain is  
defined to have a negative value.

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11. A quantum semiconductor device as  
claimed in claim 1, wherein said semiconductor  
substrate comprises any of InP and GaAs.

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12. A quantum semiconductor device as  
20 claimed in claim 1, wherein said semiconductor  
substrate carries a first electrode, a first cladding  
layer being provided between said semiconductor  
substrate and said active layer, and a second  
electrode is provided on said active layer via a  
25 second cladding layer.

30 13. A quantum optical semiconductor device  
as claimed in claim 1, wherein said quantum structure  
causes interaction with TM-mode optical radiation and  
TE-mode optical radiation with respective proportions,  
said proportion of interaction with a TM-mode optical  
35 radiation being equal to or larger than said  
proportion of interaction with a TE-mode optical  
radiation.

14. A quantum optical semiconductor device,  
comprising:

a semiconductor substrate; and

an active layer formed on said semiconductor  
5 substrate and including a quantum structure therein,  
said quantum structure comprising:

a first barrier layer of a first  
semiconductor crystal having a first lattice constant  
and a first bandgap;

10 a second barrier layer of a second  
semiconductor crystal formed epitaxially on said first  
barrier layer, said second semiconductor crystal  
having a second lattice constant and a second bandgap;

a plurality of quantum dots formed in said  
15 second barrier layer, each of said quantum dots  
comprising a semiconductor crystal forming a strained  
system with respect to said first and second  
semiconductor crystals and having a lattice constant  
different from said first lattice constant and a  
20 bandgap smaller than any of said first and second  
bandgaps, each of said quantum dots having a height  
substantially equal to a thickness of said second  
barrier layer,

said first barrier layer and said second  
25 barrier layer being stacked alternately such that said  
first barrier layer makes a contact with an apex of  
said quantum dot in said second barrier layer,

said first barrier layer and said second  
barrier layer having respective, different  
30 compositions.

35 15. A quantum optical semiconductor device  
as claimed in claim 14, wherein said quantum dots are  
formed of InAs, and wherein said first and second

barrier layers are formed of an InGaAsP mixed crystal.

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16. A quantum optical semiconductor device as claimed in claim 15, wherein said first barrier layer has a composition represented by compositional parameters  $x$  and  $y$  as  $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{P}_{1-y}$ , and wherein said  
10 compositional parameter  $y$  is set to 0.65 or less.

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17. A quantum optical semiconductor device, comprising:

a semiconductor substrate; and

an active layer formed on said semiconductor substrate and including a quantum structure therein,

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said quantum structure comprising:

a barrier layer of a first semiconductor crystal having a first lattice constant and a first bandgap;

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a plurality of quantum dots formed in said barrier layer, each of said quantum dots comprising a semiconductor crystal forming a strained system with respect to said first semiconductor crystal and having a lattice constant different from said first lattice constant and a bandgap smaller than said first bandgap,

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said barrier layer containing therein said plurality of quantum dots being stacked for a predetermined stack number,

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wherein said predetermined stack number is set such that a proportion of interaction of said quantum dots to optical radiation of TM-mode is equal to or larger than a proportion of interaction of said quantum dots to optical radiation of TE-mode.

18. A quantum optical semiconductor device as claimed in claim 17, wherein said barrier layer has a thickness exceeding a height of said quantum dots.

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19. A quantum optical semiconductor device as claimed in claim 17, wherein said semiconductor  
10 substrate and said barrier layer are formed of GaAs, said quantum dots are formed of InAs, and wherein said predetermined stack number is about eight.